Left-handed Meta-material Lens for Ultra-high Resolution Biomedical Imaging

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Summary

The objectives of this project are to investigate the unique physical characteristics of left-handed meta-materials (LHM's) and to create novel designs for biomedical imaging and other applications. LHM's are a new class of composite material that were first developed by researchers at the University of California at San Diego in 2000. They constructed an LHM as shown in Figure 1 consisting of a periodic array of metallic ring resonators and wires. For microwave radiation at wavelengths about ten times a cell length, this configuration provides negative effective values of electric permittivity and magnetic permeability. This results in a negative index of refraction and theoretically creates interesting physical properties not observed in nature. For example radiation should bend or refract in the opposite direction from the normal. In this project, we are specifically investigating the application of this unique refraction property of LHM's. The negative index of refraction should enable a flat lens as shown in Figure 2. The advantage of a flat lens is that the focal length can be varied by simply changing the distance between the lens and the wave source. We are exploring applications of a flat lens for biomedical imaging and detection applications.

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Status

We have constructed a LHM based on the geometry of Figure 1 and have started measurements to determine whether a flat lens can focus microwave radiation. Computationally, we have developed a model of LHM's with the commercial three-dimensional electromagnetic simulation code Microwave Studio. This has enabled us to design and explore new geometries for LHM's. We have developed a second design optimized for frequency bandwidth which we expect to build and test soon. Finite element models are being developed and an optics ray tracing code is being utilized to create new lens designs. We will create, design, and test other LHM configurations that are more amenable for construction at shorter wavelengths and continue to investigate new applications.

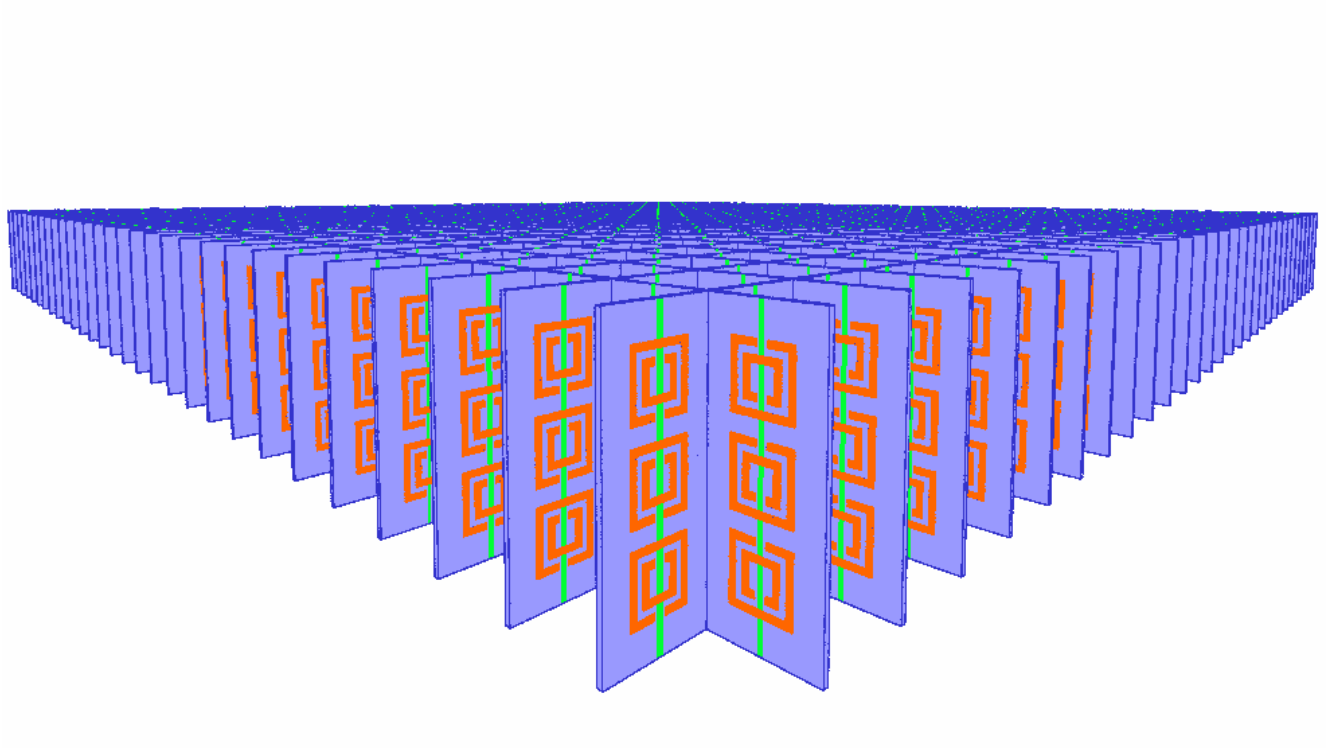

Figure 1. Left-handed metamaterial (LHM) array based on Shelby et al., "Microwave transmission through a two-dimensional, isotropic, left-handed metamaterial," *Applied Physics Letters*, 22 January 2001. Copper rings and wires are mounted on interlocking sheets of circuit board. With a unit cell width of 5 mm, this geometry has left-handed properties at microwave frequencies between 10 and 11 GHz.

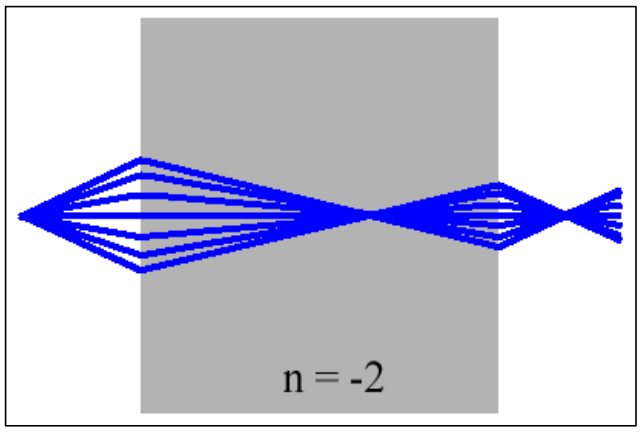

Figure 2. A flat left-handed meta-material lens with a negative index of refraction (n = -2) can focus electromagnetic radiation. The focal length can be changed by simply changing the distance between the wave source and the lens.